

U.S. DEPARTMENT OF ENERGY
OFFICE OF FOSSIL ENERGY
NATIONAL ENERGY TECHNOLOGY LABORATORY



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DOE's TURBINE RESEARCH TARGETS NATIONAL GOALS FOR ENERGY SECURITY AND THE ENVIRONMENT

The Office of Fossil Energy's combustion turbine research program at NETL responds to increasing U.S. demand for clean, efficient, and affordable power. By developing advanced, viable turbine technologies for use in coal-fired power plants, the program provides new options to meet the nation's future demands for electric power. Energy security is enhanced by the turbine's fuel flexibility which minimizes impact of natural gas price spikes and allows the use of domestic resources like coal and biomass. The advanced turbine can also be coupled with a fuel cell in a hybrid system offering dramatic efficiency improvements over conventional technologies for power generation while also reducing environmental impacts.

Project descriptions can be found at www.netl.doe.gov/scng.

Turbine Research at NETL Targets Three Key Initiatives for Energy and the Environment:

- 1. Clear Skies Initiative:** Clear Skies is a comprehensive policy to reduce emissions of SO_x, NO_x, and mercury from the power generation sector.
- 2. Climate Change Initiative:** The goal of this voluntary program is to cut U.S. greenhouse gas (GHG) emissions and reduce GHG intensity 18% by 2012.
- 3. Energy Security:** This program seeks to strengthen energy diversity by keeping coal part of the energy mix as a key fuel for power generation.



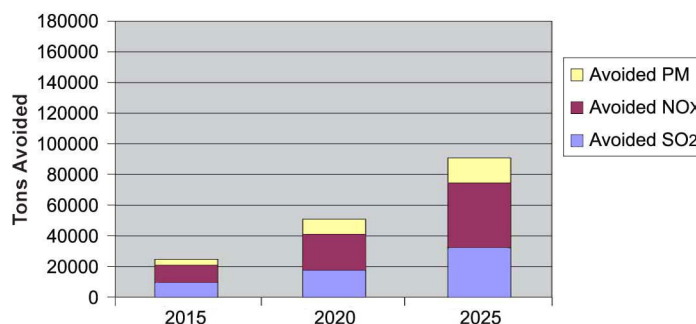
Interim Benefits

Consumers needn't wait for advanced coal plants to be commercialized to realize the benefits of improved turbine performance. Advances in turbine technology, resulting from NETL's previous turbine program, are making their way into existing plants providing real public benefits now. If by 2005, a mere ¼ of the existing turbine fleet is infused with advances to technology as the result of NETL's turbine program (assume an 8% improvement to combined cycle efficiency), emissions are reduced by 2.5 million tons/year for CO₂ and 531 tons/year for NO_x.

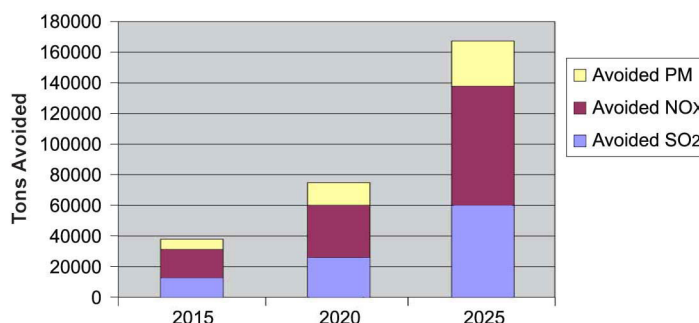
Turbines: Clear Skies

Advanced turbine technology is key to achieving the high performance of advanced coal gasification combined cycle (IGCC) plants. These plants significantly reduce emissions of SO₂, NO_x, and particulate matter when compared to conventional technologies for central power generation. In one analysis that assumes Clear Skies Initiative emission caps are met, deployment of IGCC power plants, which rely on fuel flexible gas turbine technology, is projected to be 67 GW by 2025.¹ Compared to the best supercritical pulverized coal power plant, the IGCCs result in a 90,000 ton reduction of combined NO_x, SO₂, and particulate matter by 2025. If wellhead gas prices rise to \$7.50 per million cubic feet by 2025 (compared to \$4.11 in the Clear Skies Case), the market for these advanced coal-based power plants grows to 125 GW¹, reducing emissions by more than 165,000 tons.

Avoided Emissions: Clear Skies Case



Avoided Emissions: High Gas Price Case

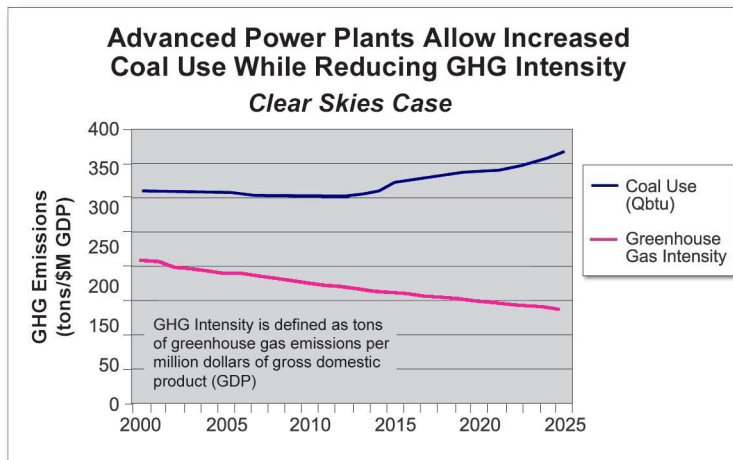


Turbines: Climate Change

Increasing efficiency at power plants offers one of the most promising ways of reducing greenhouse gas intensity to the levels targeted by the Climate Change Initiative. Seemingly small increases in power plant efficiency can lead to large

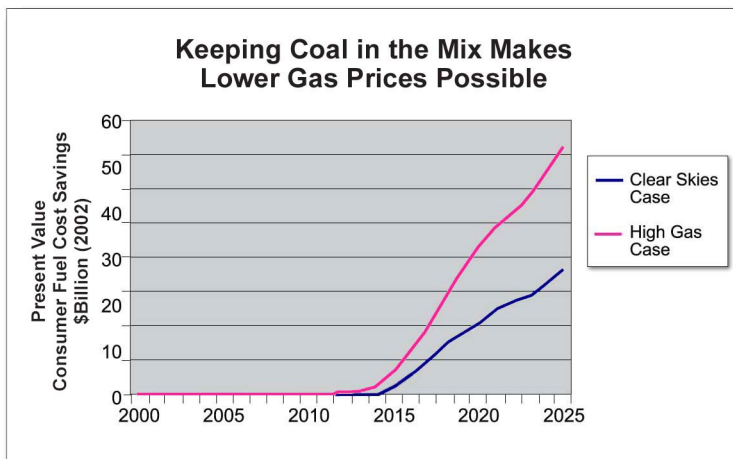
¹ Internal FE Benefit Analysis. Benefits are based on an analysis using EIA's National Energy Modeling System (NEMS). Model inputs were updated using DOE/FE's program targets for IGCC power systems using advanced turbines and cases with and without these technologies were compared.

emissions reductions. Higher efficiency also means reduced fuel consumption. By 2015, fuel cell-turbine hybrids will be available, pushing efficiencies to 75% LHV (68% on HHV basis) for natural gas-based systems and 60% HHV for coal-based systems. These hybrids will be a vital component of revolutionary future fossil-fueled power generation plants that will have near zero emissions. The use of advanced turbines in power plants of the future will allow for carbon containing gases (such as CO₂) to be generated in a concentrated form, making it easier and cheaper to capture. These technologies are a stepping stone to carbon sequestration. The following figure shows how advanced coal-fired power systems can continue to be used without negative impacts on the environment.



Turbines: Energy Security

Fuel flexibility allows for increased versatility and the use of abundant domestic resources including coal. Keeping coal in the power generating mix reduces demand for natural gas, putting downward pressure on gas prices resulting in large cost savings for residential, industrial, and commercial consumers of natural gas. The following figure illustrates the large consumer fuel cost savings that accrue when advanced power plants are deployed.



Benefits of Advanced Turbines

By 2025, using advanced turbines for central power generation provides annual benefits equivalent to:

- **NO_x**
Removing nearly 2 million cars from the road
- **SO₂**
Avoiding sulfur emissions equal to those of 1,800 MW of today's grid-supplied power
- **CO₂**
Retiring about 43 aging 500-MW coal-fired power plants
- **\$\$**
Enough cost savings to heat, cool and power over 3 million homes for 1 year

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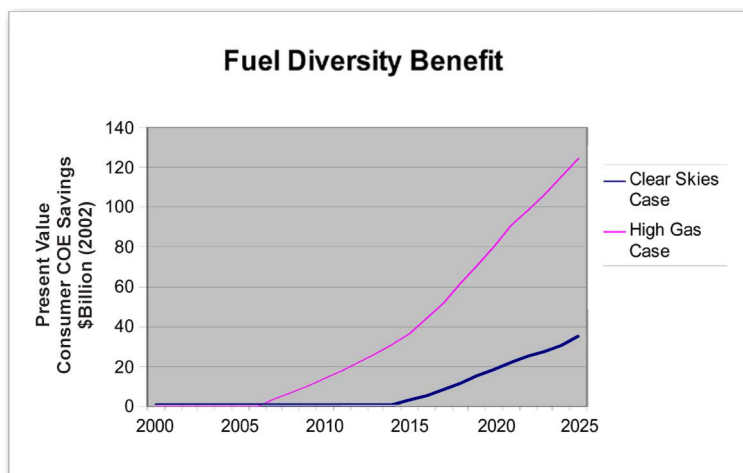
Across all sectors of the economy, U.S. businesses lose more than \$119 billion a year to power outages and poor power quality.² Turbines provide cost-effective reliable, high quality power that can help to reduce these losses. DOE's turbine research is developing innovative fuel-flexible turbines that will make turbine-based power plants among the most reliable sources for central generation. Turbines can quickly respond to increased demand, because they have a relatively short construction lead time when compared to other technologies.

Why Do We Need a Federal Program for Turbine R&D?

The energy industry continues to cut investment in R&D activities and this trend is likely to continue. Private sector R&D will likely be focused on improving profitability by developing only incremental upgrades to basic turbine products. Government investment, in the form of cost-shared partnerships, provides an incentive for industry to develop high-risk, advanced technologies. This incentive is necessary to accelerate the development of fuel flexible, highly reliable, and efficient systems that will provide cost-effective power generating options that offer the public both environmental and energy security benefits.

Using advanced power systems for central generation will reduce the cost of electricity (COE) for consumers, saving billions of dollars each year. Recent analyses project that benefits to consumers could be \$34 – \$125 billion depending on future natural gas prices.¹ Fuel flexible turbines are an enabling technology for the development of highly efficient and clean advanced power generation.

Using advanced power systems based on highly efficient fuel flexible turbines reduces the cost of electricity for consumers, saving billions of dollars each year, and offers the public both environmental and energy security benefits.



² Consortium for Electric Infrastructure to Support a Digital Society (CEIDS). June, 2001. "The Cost of Power Disturbances to Industrial and Digital Economy Companies Executive Summary." Prepared for the Electric Power Research Institute (EPRI).